### Activity 6.5.5 Constructive and Destructive Interference

In physics, the term interference is used to describe the superposition of several waves traveling through the same region of space.

You may have seen this effect at the lake or ocean. One boat may create a series of waves, and nearby another boat creates another series of waves. If the waves coincide, that is if the two waves come together at their peaks, then the wave that comes from the joining of the two waves is higher in amplitude than the two single waves. If the waves come together so that the peak of one wave joins the trough of the other wave, then the waves seem to cancel each other out.

In chemistry, interference occurs in the interaction of molecular orbitals because electrons in orbitals have wave characteristics. Waves of the same type interact with each other, enhancing or diminishing the amplitude of the resultant wave.

In music, we can add two musical notes together to obtain a chord. In music, we can add two musical notes together to obtain a chord. When we use sine function to model sound, we can use air pressure as the dependent variable and time as the independent variable. Two notes that coincide will sound louder, because the amplitude will increase; whereas two sounds that are exact opposites may cancel each other out as in noise canceling headphones.

This activity examines interference using the sine function.

**Constructive Interference**

1. Complete the following chart.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| x | 0 | π/4 | π/2 | 3π/4 | π | 5π/4 | 3π/2 | 7π/4 | 2π |
| y1 = sin(*x*) |  |  |  |  |  |  |  |  |  |
| y2 = 2 sin(*x*) |  |  |  |  |  |  |  |  |  |
| y3=sin(*x*) + 2sin(*x*) |  |  |  |  |  |  |  |  |  |

Table 1

1. Graph the functions y1 = sin(*x*) and y2 = 2 sin(*x*) on a single graph paper.

1. Plot the points from Table 1 for y3 = sin(*x*) + 2sin(*x*) on the same graph from #2.
2. Now use your graphing calculator to observe the graph of y3= sin(*x*) + 2sin(*x*).

**Attach one graph with the sketches from #2 - 4 on it. Provide answers to # 5 and 6 on the same sheet of paper.**

1. Simplify the expression: sin(*x*) + 2sin(*x*)*.*
2. Explain what happens when sin(x) is added to 2sin(x)*.*  Use your numerical results from #1 and your graphical results from #3 or 4, and your symbolic results from #5 in your explanation.

**Destructive Interference**

1. Complete the following chart.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| x | 0 | π/4 | π/2 | 3π/4 | π | 5π/4 | 3π/2 | 7π/4 | 2π |
| f(x) = 3 sin(*x*) |  |  |  |  |  |  |  |  |  |
| g(x) = −sin(*x*) |  |  |  |  |  |  |  |  |  |
| y3 = 3sin(*x*) + (−sin(*x*)) |  |  |  |  |  |  |  |  |  |

Table 2

1. Graph the functions y1 = 3sin(*x)* and y2 = −sin(*x*) on a single graph paper.
2. Plot the points from Table 2 for y3 = 3sin(*x*)+ (−sin(*x*)) on the same graph from #8.
3. Now use your graphing calculator to observe the graph of y3= 3sin(*x*) + (−sin(*x)*). Sketch the graph of *f*(*x*) + *g*(*x*) = 3sin(*x*) + (sin (*x)*) on the same graph. The sum function should coincide with your plotted points from Table 2.

**Attach one graph with the sketches from #8 - 10 on it. Provide answers to #11 - 13 on the same sheet of paper.**

1. Simplify the expression: 3sin(*x)* + (−sin(*x*)).
2. Explain what happens when 3sin(*x)* is added to -sin(*x*). Use your numerical results from #7, your graphical results from #9 or 10, and your symbolic results from #11 in your explanation.
3. The mathematical model for a sound is y = sin2x. What is the model of the signal that your noise canceling headphones should play?

**Summary**

1. Why do you think that the sum, sin(*x)* + 2sin(*x)*, is an example of ***constructive*** interference while the sum, 3sin(*x)* + (−sin(*x)*), is an example of ***destructive*** interference?
2. Figure 1 below shows the three graphs of y = sin(*x)*, y = sin(2*x*), and y = sin *x* + sin(2*x*) [pictured in bold]. Notice that we are now varying the period of each sine function. For the following questions, give *x* values accurate to 2 decimal places. You may do this problem with your calculator by graphing y1 = sin(x), y2 = sin(2*x*), and y3 = sin *x* + sin(2*x*), or you can do this numerically.



Figure 1

1. On which intervals does constructive interference occur?
2. On which intervals does destructive interference occur?